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in conjunction with the negative or lower end of the needle. This is continued from high to low and from low to high water and from day to day, the result being recorded as read off. The mechanical difficulties in the construction of the machine are very great, but not considered insuperable.

ON THE DEFICIENCIES OF METEOROLOGICAL WORK IN DATA OF VALUE TO AGRICULTURE, AND MEANS FOR SUPPLYING THEM.

By WILLIAM MCMURTRIE.

Meteorological records, as they are and have been and are being made, are deficient in many of those data which have the most important influence upon farm crops. Temperatures are recorded, but they are always observed in the shade. Rainfall is given, but often in such a way as to render its record of no value in the study of the development and condition of crops, because no indication is given as to the way in which it is distributed; light being of little importance to meteorologists generally, while it is one of the most potent factors in the development of vegetable and animal life, has been almost completely ignored. Late investigations have proven conclusively the importance of the tension of atmospheric electricity upon vegetation, and it should be regularly observed and recorded. In fact, meteorologists have principally confined themselves to the record and study of such conditions as enable them to predict the approach and occurrence of storms, thus looking more to the commercial than to the cultural side. Gasparin was the first to call attention to the importance of the relations of Meteorology to agriculture, and he has had at least two active followers—Quetelet in Belgium, and Marie Davy in France. Through the instrumentality of the latter there has been established, near Paris, an observatory of Agricultural Meteorology, where observation and record of all the conditions above named is made. The results already obtained have shown great practical value, and worthy of the means and labor required in securing them. In this country we have nothing similar to it. Our Signal Bureau, as nearly perfect as may be for the purposes for which it was designed, is devoted to the record and study of those observations as will render possible the prediction of future conditions which may affect human affairs, than such as may influence the development of crops. Besides this, the number of stations at which observations are made in this country is too limited, being not over 800, while for agricultural work 3,000 would not be excessive. Additional work should, therefore, be carried on, and observations at a larger number of stations made and recorded, to be discussed in connection with the records of observations made upon the condition of the crops. The nature of the work is such that it should be undertaken by the Department of Agriculture, and the organization of the latter with the 2,300 reporters it already employed would be well adapted to it. Fortunately, General Le Duc, the Commissioner of agriculture, is in favor of the establishment of such work in the Department, but will require congressional support to enable him to do so. The plan of work suggested by the author is as follows: 1. The establishment of a system of observation and record among the reporters of the Department of Agriculture, and others whose co-operation could be secured throughout the United States and Territories, with instructions to observers to keep careful records of the conditions of atmospheric pressure, temperature in its various relations, relative humidity, evaporation of moisture, winds, light, tension of atmospheric electricity, occurrence of dews, fogs and frosts, and report them at stated intervals of time to the Department for consideration and permanent record. 2. The collection of meteorological records from every part of the world, from which to construct detailed tables showing the relations of all the conditions named above, and may influence the growth and health of vegetation. 3. The construction of maps showing the geographical distribution of crops, to be used in connection with the meteorological or climatic data to be collected.

PRELIMINARY ACCOUNT OF A SPECULATIVE AND PRACTICAL SEARCH FOR A TRANS-NEPTUNIAN PLANET.

By D. P. TODD, M. A., Assistant in the Office of the American Ephemeris and Nautical Almanac.

So early as the year 1834, HANSEN was credited with expression of the opinion, in correspondence with the elder BOUVARD, that a single exterior planet would not account for the differences between the tabular and observed longitudes of the planet Uranus. Dr. GOULD, however, in his "Report on the History of the Discovery of Neptune," says: "I have the authority of that eminent astronomer himself (HANSEN) for stating, that the assertion must have been founded on some misapprehension, as he is confident of never having expressed or entertained that belief."

Professor PEIRCE's criticism of the investigations of LE VERRIER, to the effect that his predicted orbit of Neptune was so widely discordant from its observed orbit as to indicate that his computations did not pertain to the actual disturbing planet, elicited from him the reply that the perturbations of Uranus due to a possible planet exterior to Neptune might readily cause an uncertainty of 5" to 7" in the fundamental data of his research.

In 1866, the Smithsonian Institution published the general tables of Neptune, by Professor Newcomb. In the investigation of its orbit the author proposed: "3. To inquire whether those motions [of Neptune] indicate the action of an extra-Neptunian planet, or throw any light on the question of the existence of such a planet." He concludes (page 73) that it is "almost vain to hope for the detection of an extra-Neptunian planet from the motions of Neptune before the close of the present century."

In 1873, the Smithsonian Institution published the general tables of Uranus, by Professor Newcomb. His success in the treatment of the theory of Uranus was such that astronomers generally may be said to have been satisfied from the smallness of the longitude-residuals, that there existed no evidence of perturbative action upon Uranus other than that actually taken into account in the construction of the tables. It is well known, however, that since the publication of these tables the error of longitude has been increasing.

Sometime in the spring of 1874, the first preliminary outline of the very simple method which I have here employed in the treatment of planetary residuals with reference to exterior perturbation, suggested itself to me. For more than three years very little opportunity offered for consideration of the problem of a trans-Neptunian planet. In August, 1877, however, I began to devote the larger portion of my leisure time to the theoretic side of the question. It was soon evident that no certain hold upon any possible cause of exterior perturbation could be obtained from the residuals of Newcomb's tables. And I may remark here that I have consequently chosen the term *speculative* rather than *theoretic* as applying more fitly to the investigation which preceded the actual telescopic search.

It did not seem to me that the magnificent researches of Le Verrier and Adams on the perturbations of Uranus should be taken as models in the present investigations, for two reasons:

(1) The residuals of longitude which must form the basis of the investigation are not sufficiently well marked to justify the execution of so laborious a research, especially if it be found that a simple, rational treatment, unencumbered with the refinements of analysis, may be fairly interpreted as indicating the position of an exterior perturbing body with merely a rough approximation.

(2) Even in the case of Uranus, and the theoretic search for Neptune, where the residuals of longitude were very strongly marked, many of the elements pertaining to the disturbing planet, which Adams and Le Verrier sought to determine theoretically, turned out afterward, when their real values became known, to have been indicated with only meagre precision. Much less should we now expect these elements to be given with any certainty in the case of a planet exterior to Venus.

This provisional treatment of the residuals of Uranus was undertaken, then, as a preliminary to the proposed